Demo: Distributed Video Coding Applications in Wireless Multimedia Sensor Networks

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***Abstract*— Novel distributed video coding (DVC) architectures developed by the IBBT DVC group realize state-of-the-art video coding efficiency under stringent energy restrictions, while supporting error-resilience and scalability. Therefore, these architectures are particularly attractive for application scenarios involving low-complexity energy-constrained wireless visual sensors. This demo presents the scenarios, which are considered to be the most promising areas of integration for IBBT's DVC systems, considering feasibility and commercial applicability.**

Keywords-Distributed video coding; application scenarios; wireless multimedia sensor networks.

I. INTRODUCTION

Conventional predictive video coding principles, adopted by the widely spread ISO MPEG standards and the ITU-T recommendations, e.g., H.26x [1], are struggling to simultaneously offer high-performance and low-cost video encoding for wireless visual sensor network applications [2]. These traditional architectures assign the majority of the total computational burden to the sensor node (encoder), while maintaining a simple decoder. On the contrary, the emerging distributed video coding (DVC) technology [3], employs simple yet efficient encoders, combined with more complex decoders, thereby relocating the complexity to the base station. Besides de facto favoring low-complexity sensors, DVC schemes inherently offer increased error resilience with respect to traditional video coding systems [2]. Furthermore, DVC facilitates efficient multi-view video coding enabling the exploitation of inter-sequence correlation at the decoder, which minimizes inter-sensor communication overhead.

The work of [4] has investigated the applicability of DVC systems in a wide range of practical multimedia scenarios. This demo paper focuses on the value of the state-of-the-art DVC technology – developed by the IBBT DVC group – to promising wireless visual sensor network applications.

II. SENSOR-ORIENTED DVC APPLICATIONS OF INTEREST

A. Wireless Surveillance Sensors

In this scenario, networks of wireless visual sensors are deployed to monitor specific scenes, providing security and surveillance. The acquired information is gathered by a central node for decoding and processing. In a multi-view surveillance network scenario, stereoscopic coding with disparity maps generated at the decoder can exploit inter-view correlations without inter-camera communication. In combination with tracking and detection algorithms the developed IBBT DVC systems can provide spatial, temporal, and quality scalability.

The most important wireless network surveillance applications are characterized by a wide variety of scene content, ranging from complex motion sequences, e.g., crowd or traffic monitoring, to surveillance of scenes mostly devoid of significant motion, e.g., fire and home monitoring. IBBT's DVC architectures are able to cope with such varying motion conditions. Compared to the state-of-the-art [3], IBBT's DVC systems yield compression gains of up to 2.48% Bjøntegaard (BD) rate reduction in low motion sequences (Silent, GOP8). When highly irregular motion content is coded, the gains increase up to 32.85% BD rate reduction in Ice (Fig. 1), which is a representative complex motion surveillance sequence.

B. Distributed Multimedia Streaming from Wireless Sensors

DVC constitutes a key component to realize many-to-many live video streaming scenarios over commercial wireless networks, which implies the need for optimal error resilient video streams, tailored to specific needs in terms of quality, frame-rate, resolution, and computational capabilities of a set of recorders. For example, athletes could be equipped with a wireless visual sensor, providing an individual live stream. A multi-sensor version of IBBT's DVC can facilitate uplink oriented many-to-one video communications up to a commercial base station. Such a scheme maintains low computational requirements at the distributed sensor nodes, while ensuring fast and highly efficient error resilient video communications. The base station then transcodes the DVC streams to a conventional predictive coding format with low-complexity decoding features, providing a down-link oriented one-to-many video stream for further dissemination. Such a video communications scenario centralizes the computational complexity in the fixed network infrastructure.

C. Wireless Capsule Endoscopy

In order to diagnose diseases of the human gastrointestinal (GI) tract, standard examination techniques visualize the esophagus and stomach, i.e., gastroscopy, and the colon, i.e., colonoscopy. However, the small bowel remains mainly inaccessible to being probed with such invasive diagnostic methods. Recent advances in electronics, micro-system's

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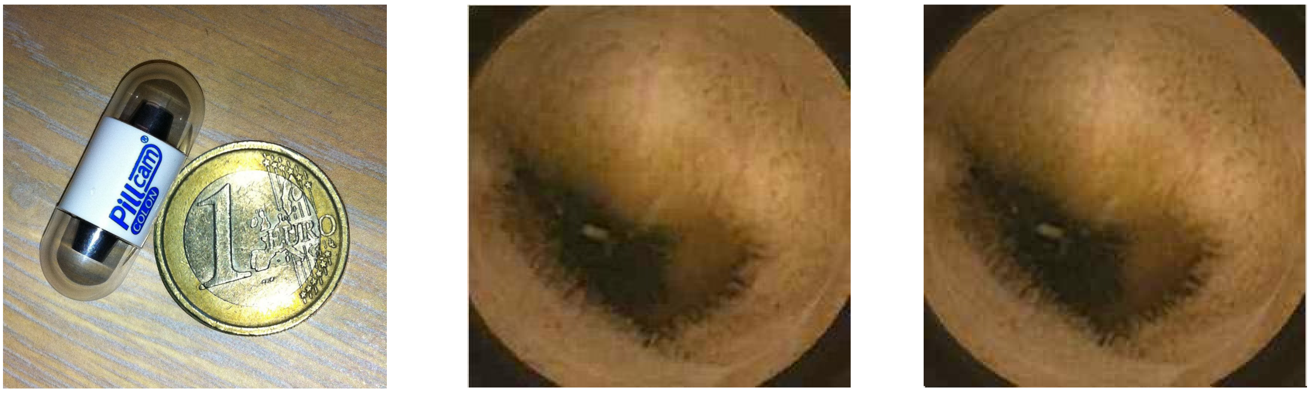
(a) (b)

Fig. 1. Visual comparison for Ice, QCIF, 15Hz, GOP16: (a) coded with DISCOVER (185.7kbps, 31.9dB), (b) coded with the IBBT DVC codec (176.9kbps, 34.8dB).



(a) (b) (c)

Fig. 2. (a) The Pill-Cam COLON capsule endoscope of Given Imaging. Visual performance for capsule endoscopic video coded at 125kbps with: (b) Motion JPEG, 38.6dB, (c) the IBBT's DVC codec, 39.3dB.

manufacture, and wireless communications have led to the design of wireless capsule endoscopes – see Fig. 2(a). A capsule endoscope consists of a miniature battery, an effective illumination source, a video camera, and an RF transmitter. Once swallowed, the capsule transmits video of the esophagus, stomach and small intestine to a sensor array placed around the patient's abdomen. Currently, a major aim of capsule endoscope vendors, e.g., Given Imaging, Olympus Optical, is to obtain highly efficient and error-resilient video compression, at low power consumption, and also to achieve further miniaturization of the capsule. Contemporary capsule integrated video circuits occupy conventional intra-frame coding schemes, e.g., Motion JPEG. The IBBT's DVC group is the first to design a novel video coding architecture for wireless endoscopy based on the DVC principles [5].

Extensive evaluation of the developed DVC system using abundant capsule endoscopic video material shows notable and consistent compression gains over several state-of-the-art standard video codecs at the benefit of significantly reduced encoding complexity – see Fig. 2(b) and (c). In more detail, results report BD rate gains of 9.33% and 12.41% against Motion JPEG and H.264/AVC Intra, respectively. Compared to the state-of-the-art DISCOVER [3] codec, IBBT's DVC scheme delivers a vast BD rate reduction of up to 43.3%.

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III. CONCLUSIONS

This demo paper enumerates important wireless visual sensor applications for future deployment of the IBBT DVC group technology. The developed technology outperforms not only competitive distributed video codecs [3], but also state-of-the-art predictive video coding architectures [1].

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